A research consortium seeks to automate the process of designing medical lab on a chip systems.

Several institutes at Johannes Kepler University Linz, Austria, are cooperating with ESS, the Ernst Wittner Gesellschaft m.b.H. and the Software Competence Center Hagenberg. The consortium now wants to develop similar methods for chip labs.

In the future, entire designs of microfluidic systems will be generated automatically simply by specifying the desired operations: liquids should be mixed, samples should incubate for a certain period of time, etc.

“Automating the design of medical lab on a chip systems is not just about saving costs. The aim is then to use this process as a basis for the large-scale fabrication of such chip labs,” Professor Robert Wille, consortium leader and head of the Institute for Integrated Circuits (JKU) in Linz, Austria, explains. He is supporting the project with over €1.4 million.

At Johannes Kepler University, research on microfluidics has been ongoing for many years. The envisaged design process is based on the experience gained so far.

“Classic computer chips, which have highly complex units with sometimes millions or even trillions of components, are the role model. One example is transistors. These must be correctly placed and connected, among other things. Still, numerous automatic methods have already been established that make it possible to produce these chips at the push of a button. The consortium now wants to develop similar methods for chip labs,” Wille explains.

“We have already established a method that automatically creates circuits out of individual steps on the chip. This is now being used to develop a virtual test laboratory that will run on a computer,” Wille adds.

For the construction of the tool, different possibilities are being investigated. For simpler test laboratories, the consortium is investigating the automatic design of circuits using conventional circuit simulators. "They can already do the job well," Wille says.

When circuits become more complex, results of simulations are implemented in a virtual test laboratory. "You can then create a circuit on the virtual test laboratory that looks like the circuit you would produce on the chip," Wille says.

The advantage of a simulation is already clear here. You can quickly test whether the design works or is even better suited for the task it has to fulfill. You don’t have to build the chip, test it, and optimize it over and over again. And this is where the automatic design comes in, Wille says.

"When they branch, how long they flow through meanders, etc." Wille explains. But also, complex issues, such as how the simulations are supposed to run, the right type of materials should be used, or the fluids should be mixed in the correct order. The automatic design is not limited to circuits but also offers the advantage that this information is automatically transferred to the chip.

This will make it easier to bring further medical analyses and examinations from the lab to the bedside. Metals, proteins and other substances have to be processed with complex equipment, cost-intensive chemicals and high personnel costs. At the point of care, meaning on the patient. The COVID-19 pandemic recently showed that this is an urgent need.

"Approaches are being developed that can be of use on an individual basis, meaning in the context of each patient’s disease. These are not only applicable for research, but also for the diagnosis and treatment of diseases. At the moment, however, there is still a lot of work to do, Wille says. The main challenge is to control the processes, mix the liquids, incubate samples and perform chemical analysis in chips that are small enough to be used in a virtual test laboratory on a chip.

"The disadvantage compared to computer chips is that when they branch, how long they flow through meanders, etc." Wille explains. But also, complex issues, such as how the simulations are supposed to run, the right type of materials should be used, or the fluids should be mixed in the correct order. The automatic design is not limited to circuits but also offers the advantage that this information is automatically transferred to the chip.

This is because effects that are often neglected in classic fluid mechanics can dominate at this scale. For example, gases are assumed to behave differently than macroscopic fluids in the smallest space. The behavior of fluids is, however, very different. At that point, physical principles previously abandoned in fluid mechanics are of utmost importance. This is why micromachining is not a simple extension of the macroscopic fluid mechanics. This is why even experts in fluid mechanics now need to know about micromachining, Wille says.

"We have already established that make it possible to produce these chips at the push of a button. The consortium now wants to develop similar methods for chip labs. This will make it easier to bring further medical analyses and examinations from the lab to the bedside. Metals, proteins and other substances have to be processed with complex equipment, cost-intensive chemicals and high personnel costs. At the point of care, meaning on the patient. The COVID-19 pandemic recently showed that this is an urgent need.

"When they branch, how long they flow through meanders, etc." Wille explains. But also, complex issues, such as how the simulations are supposed to run, the right type of materials should be used, or the fluids should be mixed in the correct order. The automatic design is not limited to circuits but also offers the advantage that this information is automatically transferred to the chip.

\[ \text{Redaktion: Hildegard Suntinger, Testalize.me} \]

\[ \text{© Innovation Origins 2021} \]